GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: April 24, 1979

Project Title: ~~Research Initiation~~ - A Fundamental Investigation into the Fatigue of Elastohydrodynamic Components

Project No: E-23-645 Steam Card

Project Director: Dr. Richard K. Kunz

Sponsor: National Science Foundation

Agreement Period: From 4/15/79 Until 9/30/81 (Grant Period)

Type Agreement: Grant No. ENG-7908006, dated 4/13/79

Amount: $31,972 NSF
4,328 GIT (E-23-338)
$36,300 TOTAL

Reports Required: Annual Progress Report; Final Project Report

Sponsor Contact Person (s):

Technical Matters

NSF Program Officer

Dr. Clifford J. Astill, Program Director
Solid Mechanics Program
Engineering Mechanics Section
Division of Engineering
Directorate for Mathematical and Physical Sciences, and Engineering
National Science Foundation
Washington, D. C. 20550
202/632-5787

Contractual Matters
(thru OCA)

NSF Grants Official

Ms. Mary Frances O'Connell
MPE/BBS/SE Branch
Division of Grants and Contracts
Directorate for Administration
National Science Foundation
Washington, D. C. 20550
202/632-2858

Defense Priority Rating: N/A

Assigned to: Engineering Science & Mechanics (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director–EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other

CA–3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date July 12, 1983

Project Title: ~~Research Initiation~~ - A Fundamental Investigation into the Fatigue of Elastohydrodynamic Components

Project No: E-23-645

Project Director: Dr. Richard K. Kunz

Sponsor: National Science Foundation

Effective Termination Date: 9/30/81

Clearance of Accounting Charges: 9/30/81

Grant/Contract Closeout Actions Remaining:

NONE

- ☐ Final Invoice and Closing Documents
- ☐ Final Fiscal Report
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

Assigned to: Engineering Scinece Mechanics (School/~~Laboratory~~)

COPIES TO:

Administrative Coordinator	Research Security Services	EES Public Relations (2)
Research Property Management	Reports Coordinator (OCA)	Computer Input
Accounting	Legal Services (OCA)	Project File
Procurement/EES Supply Services	Library	Other Kunz

FORM OCA 10:781

F23-645

Research Initiation

A FUNDAMENTAL INVESTIGATION INTO THE FATIGUE OF ELASTOHYDRODYNAMIC COMPONENTS

Annual Progress Report for
National Science Foundation Grant No. ENG-7908006

Period Covered: 4/15/79 - 4/14/80

Richard K. Kunz, Project Director
School of Engineering Science and Mechanics
Georgia Institute of Technology
Atlanta, Georgia 30332

The primary objective of this investigation is to analytically determine the stress fields in the solid components of both two and three-dimensional elastohydrodynamic systems, for the purpose of studying the fatigue of such components. The calculation of the pressure distributions on the surfaces of the solid bodies from experimental film thickness data, using a technique developed by the principal investigator and co-workers in a previous investigation, forms the basis for the analysis.

The problem of determining the stress fields has been broken down into consideration of the stress boundary-value problems for four separate bodies subjected to normal surface tractions: the infinite cylinder and the half-plane in the two-dimensional case; and the half-space and the sphere in the three-dimensional case. In addition, it has been proposed that the effects on the stress fields due to tangential surface tractions, arising from shearing of the lubricant in the conjunction between the bodies, be investigated for each of the four fundamental cases. During the period covered by this report, the following results have been obtained:

The analysis necessary for computing stresses in the cylinder has been completed, and a computer program has been developed for their numerical evaluation. Preliminary results of these calculations have been reported (R. K. Kunz and G. M. Rentzepis, "The Stress Field Generated by a Cylinder Subjected to an EHD Process", Abstracts for Research in Progress, 16th Midwestern Mechanics Conference, Manhattan, Kansas, 1979). Consistent with Hertzian theory, it has been found that the maximum shear stress occurs below the surface of the cylinder, while the principal stresses, all compressive, reach their maxima at the surface. Furthermore, new calculations based on two-dimensional film thickness data have been performed yielding pressure distributions departing significantly from Hertzian. This is an indication that analyses by previous investigators, assuming the Hertzian pressure profile in

the EHD zone, will yield erroneous stress magnitudes in these cases. Finally, the analytical work has been initiated for determining stresses in the half-plane due to the computed pressure distributions.

For the three-dimensional case, an existing program for calculating pressure distributions from experimental film thickness data has been refined and modified to yield three-dimensional plots of the pressure. Several sets of pressure distributions have been calculated from available film thickness data. These pressure fields are appropriate for use in finding the stresses in the half-plane and the sphere.

The analysis for the determination of the stresses in the half-space for a three-dimensional pressure loading has been completed, and a computer program is currently under development for numerical evaluation of the stresses corresponding to the computed pressure profiles. In addition, some preliminary analytical work for the stress field in the sphere has been initiated.

The major problem facing the project at this point is a lack of available, detailed film thickness data for the two-dimensional case. Because this configuration presents experimental difficulties not present in the three-dimensional system, apparently fewer film thickness measurements have been done for this case. Conversely, however, pressure and stress calculations in two dimensions are much simpler, and at least an order of magnitude less expensive on the computer. Hence, these results are of importance not only for their own sake, but also for the possibility of generalizing their conclusions to the more difficult three-dimensional case. However, many meaningful conclusions appear to be within reach even from the few sets of data currently available, and the search continues for more data.

A second potential problem is anticipated from the preliminary analytical work done on the sphere. The analytical results are sufficiently involved

that an undue amount of computer time may be required for their numerical evaluation. However, it is anticipated that, based in part on results obtained from the two-dimensional case, an order-of-magnitude analysis may significantly simplify the results and facilitate more practical computation.

In the coming year, it is projected that stresses in the half-plane due to normal surface tractions will be computed. In addition, a good estimate of the effect of tangential surface tractions on the stresses in the cylinder and half-plane will be incorporated into the results. It is hoped that sufficient film thickness data for the two-dimensional case will be obtained so that stress fields for a wide range of operating conditions (loads and speeds) may be computed.

In the three-dimensional problem, numerical results for the stresses in the half-space subjected to pressure loading will be computed. In this problem also, the effects of tangential surface tractions will be quantitatively evaluated. It is anticipated that comparable results for the sphere, at least for the normal loading, will also be obtained.

In addition, more work needs to be done in determining the essential information to be extracted from the stress field in order to shed further light on the possibilities of fatigue failure of elastohydrodynamic components. Comparison of these results with results of previous investigations, particularly with regard to cases in which pressures significantly depart from the Hertzian case, will also be sought.

E-23-64E

ATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I–PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program	3. NSF Award Number
Georgia Institute of Technology 225 North Avenue Atlanta, Georgia 30332	Engineering Research Initiation	ENG - 7908006
	4. Award Period From 4/15/79 To 9/30/81	5. Cumulative Award Amount $31,972

6. Project Title

Research Initiation - A Fundamental Investigation into the Fatigue of Elastohydrodynamic Components

PART II–SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

Motivated by the conviction that fatigue phenomena in non-conforming, elastohydrodynamically (EHD) lubricated machine elements are fundamentally influenced by the EHD-generated stress fields, the primary objective of this research has been an accurate determination of these stress fields. Two basic geometries have been investigated: EHD lubrication of two parallel cylinders; and EHD lubrication of two spheres.

In both cases, the problem is approached by first determining the hydrodynamic pressure field exerted on the solid components of the system. Using techniques developed in an earlier investigation, this is accomplished from experimental knowledge of the film profile, as well as the geometry and the elastic properties of the solid components. The stress fields in the solids are then obtained through the solution of the corresponding boundary-value problems of classical elasticity for the body (cylinder or sphere) subjected to known surface tractions. In particular, principal stresses and extremal values of the shear stress are sought in the highly stressed regions beneath the loading.

The principal findings may be summarized as follows: (i) In many instances, the pressure distribution differs significantly from the Hertz solution for the corresponding dry contact problems, with the maximum pressure often substantially exceeding the Hertzian maximum. (ii) The maximum shear stress occurs beneath the surface, where failures are often initiated. This maximum also may exceed that predicted by Hertzian theory in those cases mentioned above. (iii) The inclusion of tangential surface tractions due to lubricant viscosity can substantially affect both location and magnitude of the maximum shear.

PART III–TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (√)	Approx. Date
Abstracts of Theses	√				
Publication Citations				√	3/31/82
Data on Scientific Collaborators				√	3/31/82
Information on Inventions	√				
Technical Description of Project and Results				√	3/31/82
Other *(specify)*					

7. Principal Investigator/Project Director Name *(Typed)*	8. Principal Investigator/Project Director Signature	9. Date
Richard K. Kunz		12/14/81

Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. 99R0013